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THE INFLUENCE OF CHANGES IN SPRINT ABILITY ON THE SLED VELOCITY PROFILE DURING THE SKELETON START

Steffi L. Colyer[1,2], Keith A. Stokes[1], James L.J. Bilzon[1,2] and Aki I.T. Salo[1,2]

Department for Health, University of Bath, Bath, United Kingdom[1]
CAMERA - Centre for the Analysis of Motion, Entertainment Research and Applications, University of Bath, United Kingdom[2]

Sprint times are key predictors of skeleton start performance, but the effect of enhancing sprint ability on the development of sled velocity is unknown. Twelve well-trained skeleton athletes performed three dry-land push-starts and three 30-m sprints before and after 16 training weeks. Sled velocity profiles were characterised using three descriptors (pre-load velocity, pre-load distance and load effectiveness) and a sled acceleration index was used to evaluate performance. Increases in pre-load velocity and distance were related to improved sprint times. However, enhanced sprint ability did not guarantee a faster start as reductions in load effectiveness were also observed when higher velocities were attained. Coaches could supplement physical conditioning with load technique training to potentially improve the transfer of training-induced sled velocity increases across the loading phase.

KEY WORDS: acceleration, ice-track, sliding, speed, training

INTRODUCTION: Athletes begin every run in the winter sport of skeleton by explosively pushing the sled in a bent-over position for approximately 25-30 m, before launching themselves forward to load the sled and adopting a prone driving position. Faster sprinters are generally superior push-starters in skeleton (Sands et al., 2005; Colyer, 2015) and are, in turn, considered to have greater overall chances of success in competition (Zanoletti et al., 2006). For this reason, skeleton athletes' sprint abilities are routinely assessed to determine athlete potential and/or development (Bullock et al., 2009), with training programmes primarily focussed on enhancing accelerative capacity and explosive power.
Taking a greater number of steps before loading has previously been associated with faster starts during elite women's skeleton races (Bullock et al., 2008). Moreover, utilising a continuous sled velocity measurement, Colyer (2015) reported that sprint ability influences the position and velocity at which an athlete loads the sled, with faster sprint times associated with loading the sled later and with greater velocity. Improving sprint ability could, therefore, conceivably allow athletes to accelerate the sled across a greater distance and to potentially improve overall start performance. However, the influence of enhancing sprint capacity on the development of sled velocity across the start phase is yet to be explored. The purpose of this study was, therefore, to investigate how the changes in sprint ability observed across a 16-week training block influence skeleton start performance.

METHODS: Twelve (seven elite, five talent) skeleton athletes participated in this study. A local research ethics committee provided ethical approval for this research and all athletes provided written consent. Data were collected before and after a 16-week summer training period, which ended just before athletes started the ice-track season. This training period was primarily focussed on enhancing accelerative capacity, and consisted of high-velocity training, sprint-based exercises and typically two or three specific push-start sessions per week. Both testing sessions included three maximum-effort push-starts followed by 90 minutes of recovery and then three maximum-effort unresisted 30-m sprints. Schedules were consistent at both testing sessions and athletes were asked to refrain from vigorous exercise for the 36-hour period before testing. Prior to the first push-track testing session, athletes completed and documented a 30-minute athlete-led warm-up, which involved predominantly running, bounding and jumping drills. An abbreviated athlete-led warm-up was also conducted before the sprint tests. Both warm-ups were replicated at the subsequent testing session.

Push-starts were performed by pushing a wheeled sled on an outdoor dry-land push-track with a three-minute recovery between runs. A custom-built magnet encoder (Sleed; Sheffield Hallam University, United Kingdom) attached to one of the sled wheels provided the time interval for each complete turn of the wheel (every 0.1984 m). Sleed data were telemetrically transferred to a receiver and permanent photocells at the 15-m and 55-m mark recorded split times (Tag Heuer, Switzerland; 0.001s accuracy). Both data sets were stored using custom built software (Sleed, Sheffield Hallam University, United Kingdom). A video camera (Sony HC9, Tokyo, Japan) operating at 50 Hz with 1/600 s shutter speed was located next to the track approximately 10 m from the starting block and was panned to capture the entire push-start phase (from the starting block to the loading phase). The number of steps taken before loading in each push-start trial was recorded from the video footage. The 30-m sprints were performed on an indoor synthetic running track from a three-point starting position, and a three-minute recovery was also taken between runs. Photocells (Brower Timing System; Utah, USA; 0.001-s resolution) were placed on tripods on the 15- and 30-m marks at waist height. Timing was initiated when the hand was released from a touch pad placed on the starting line and split times were recorded. The time taken to reach 15 m was used as a sprint performance indicator as this has previously been shown to be the strongest predictor of skeleton start performance (Colyer, 2015).
Raw sled velocity data were exported from the Sleed software and velocity-distance profiles were plotted for each trial. The final data point before a decrease in velocity (indicative of the end of the initial acceleration phase and start of the loading phase; Figure 1) signified the pre-load time point. The post-load time point was defined as the first data point after which the increases in velocity were approximately constant (no further propulsion from the athlete, and thus it can be assumed that the prone driving position has been adopted). A sixth order polynomial was fitted from the first data point to ten points following the pre-load time point. Additionally, a linear trendline was fitted to the data from the post-load point to the final data point. Load effectiveness was calculated by extrapolating this post-load linear trend line to the pre-load time point and computing the difference between this extrapolated velocity and the actual pre-load velocity (Figure 1).

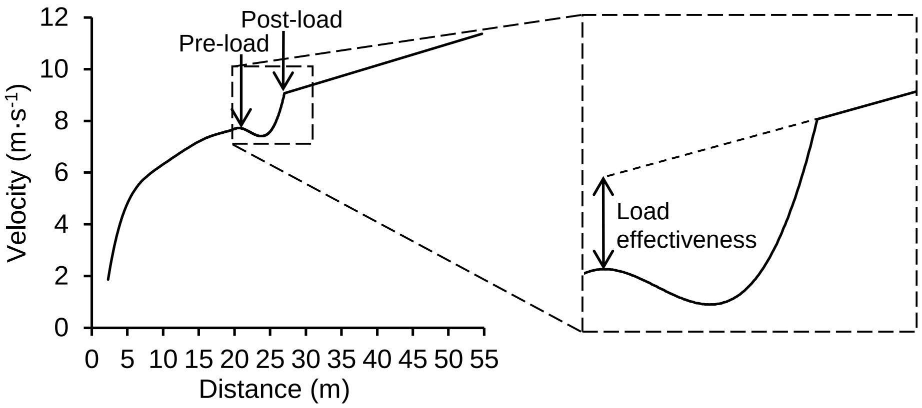

Figure 1: A schematic of a sled velocity profile during a skeleton push-start illustrating the identification of pre- and post-load time points and the definition of load effectiveness.

A sled acceleration index (Eq. 1; Colyer, 2015) was used to evaluate start performance:

$$\text{Sled acceleration index} = \frac{\text{55 m velocity}}{\text{15-55 m time}} \qquad \text{[Eq.1]}$$

For each individual athlete at both time points, mean values were calculated for all output variables (number of steps, pre-load velocity, pre-load distance, load effectiveness, sled acceleration index, 15-m sprint time) across the three completed trials. Effect sizes (±90% confidence intervals, CI) were used to assess for differences between the pre- and post-test values. Percentage differences were then computed between the mean values achieved at the two time points. Pearson correlation coefficients (±90% CI) were used to assess the associations between the percentage changes in 15-m sprint times and the percentage changes in start performance descriptors. A threshold for a practically important effect size was set at 0.2 (Hopkins et al., 2009) with values between -0.2 and +0.2 signifying a trivial effect, and clear and unclear effects defined using 90% CI, as previously suggested (Batterham and Hopkins, 2006). Similarly, a threshold of 0.1 was set for the smallest practically important correlation (Hopkins et al., 2009), through which clear (positive or negative) and unclear relationships were also defined using 90% CI.

RESULTS: Athletes took a greater number of steps and loaded at a greater distance from the block following the 16-week training period (Table 1). Additionally, higher pre-load velocities, but less effective loading phases were exhibited at the post-test time point. Overall, start performance (sled acceleration index) improved across this period.

Table 1. Start performance descriptors (mean ± SD) before and after 16 weeks of training

	Pre	Post	Effect size (±90% CI)
Sled acceleration index	2.54 ± 0.22	2.64 ± 0.21	0.46 ± 0.21 *
Number of steps	15 ± 2	16 ± 2	0.60 ± 0.31 *
Pre-load distance (m)	26.0 ± 1.9	26.8 ± 2.7	0.35 ± 0.43 *
Pre-load velocity ($m \cdot s^{-1}$)	8.2 ± 0.7	8.5 ± 0.7	0.44 ± 0.25 *
Load effectiveness ($m \cdot s^{-1}$)	0.55 ± 0.19	0.48 ± 0.16	-0.42 ± 0.30 ^
15-m sprint times (s)	2.51 ± 0.13	2.51 ± 0.13	0.03 ± 0.09

*denotes higher and ^denotes lower in post-test compared with pre-test

At a group level, sprint times did not change across the 16-week training block (0.2 ± 0.9%, mean ± SD), although these responses were heterogeneous in nature. The observed variation in changes in sprint performance did, however, appear meaningful as associations with the changes in several start performance descriptors were observed (Figure 2). Positive relationships were found between changes in sprint performance and changes in the number of steps, pre-load velocity and pre-load distance. However, improvements in sprint times were also associated with less effective loading phases. Consequently, there was an unclear association between sprint performance changes and changes in start performance (sled acceleration index).

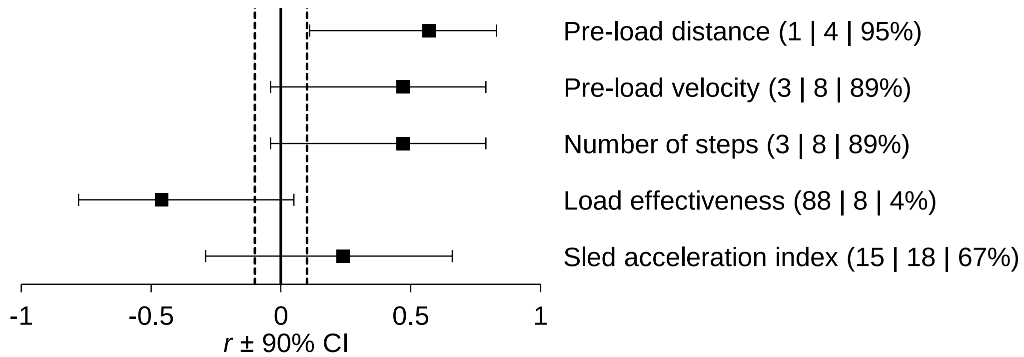

Figure 2: Relationships (r ± 90% CI) between changes in 15-m sprint time and changes in five start performance descriptors. Due to lower times indicating improved sprint performance, coefficients have been inverted for presentation purposes. Central area (r = 0.0 ± 0.1) indicates trivial zone. Percentages represent likelihoods that a relationship is negative | trivial | positive.

DISCUSSION: A 16-week training block, which focussed on enhancing accelerative capacity prior to the ice-track season, induced small changes in skeleton athletes' sprint abilities. These changes appeared to influence the velocity and distance at which an athlete loaded the sled

with improved 15-m sprint performance associated with increased pre-load distance and velocity (Figure 2). This supports previous findings, which have suggested that physical capacity regulates the position and velocity at which an athlete loads the sled (Colyer, 2015). Given the previously reported relationship between an increased number of steps taken and reduced start times on ice-tracks (Bullock et al., 2008), it may be expected that the increase in pre-load distance observed in this study would also result in a start performance improvement. However, notwithstanding the increases in pre-load velocity, improved sprint ability was not associated with overall start performance changes in this study (r = 0.26; -0.29 to 0.66, 90% CI). This appears to be due to a reduction in load effectiveness, which was also observed when sprint ability increased. Thus, the potentially beneficial changes in pre-load velocity and distance with improved sprint ability seemed to be counteracted by a negative influence on the loading phase, which may have unfavourable performance outcomes. Coaches should be aware of these interactions and ensure that any increases in pre-load velocity are not simultaneously outweighed by a reduction in an athlete's ability to effectively load the sled.
These findings suggest that athletes may differ in their ability to maintain an effective load when improving sprint performance, and thus, loading the sled at a greater distance and with higher velocity. Although regular push-track training sessions were carried out across this study period, it is possible that for some athletes there could be a delay in the translation of physical training adaptations into increased sled velocity across the entire push-start phase. As research in this area is yet to analyse the full kinematics of skeleton athletes during push-starts, the technique-based aspects which constitute a successful load remain unknown and the sled-athlete interaction warrants further investigation. If the kinematic determinants of a successful loading phase are elucidated, specific loading technique training could potentially improve the acceleration of the sled across the loading phase and facilitate the transfer of training-induced increases in sprint capacity to overall start performance enhancement.

CONCLUSION: Improving sprint ability across a 16-week training block increased the velocity and distance at which skeleton athletes loaded the sled. However, this did not necessarily result in improved skeleton start performance, as a reduction in load effectiveness was also observed when these higher pre-load velocities were attained. Consequently, coaches should not only focus on enhancing sprint ability and maximising pre-load velocity, but the subsequent effect on the loading phase should also be considered. It could be beneficial for skeleton coaches to supplement physical conditioning with load technique training.

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